Using Maximal Isometric Force to Determine the Optimal Load for Measuring Dynamic Muscle Power

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Abstract

Maximal power output typically occurs when subjects perform ballistic exercises using loads of ~30% of one-repetition maximum (1-RM). However, performing 1-RM testing prior to power measurement requires considerable time, especially when testing involves multiple exercises. Maximal isometric force (MIF), which requires substantially less time to measure than 1-RM, might be an acceptable alternative for determining the optimal load for power testing. PURPOSE: To determine the optimal load based on MIF for maximizing dynamic power output during leg press and bench press exercises. METHODS: Twenty healthy volunteers (12 men and 8 women; mean ± SD age: 31 ± 6 years; body mass: 72 ± 15 kg) performed isometric leg press and bench press movements, during which MIF was measured using force plates. Subsequently, subjects performed ballistic leg press and bench press exercises using loads corresponding to 20%, 30%, 40%, 50%, 60% of MIF presented in randomized order. Maximal instantaneous power was calculated during the ballistic exercises using force plates and position transducers. Repeated-measures ANOVA and Fisher LSD post hoc tests were used to determine the load(s) that elicited maximal power output. RESULTS: For the leg press power test, 6 subjects were unable to be tested at 20% MIF because these loads were less than the weight of the unloaded leg press sled assembly (31.4 kg). Therefore, these loads were excluded from analysis. A trend (P=0.07) for a main effect of load existed for the leg press exercise, indicating that the 40% MIF load tended to elicit greater power output than the 60% MIF load (effect size = 0.38). A significant (P<0.05) main effect of load existed for the bench press exercise; post hoc analysis indicated that the effect of load on power output was: 30% > 40% > 50% = 60% Conclusions: Loads of 40% and 30% of MIF elicit maximal power output during dynamic leg presses and bench presses, respectively. These findings are similar to those observed when loading is based on 1-RM.

Methods

Experimental Design. Subjects performed isometric leg presses and bench presses, during which MIF was measured using force plates. Subsequently, subjects performed ballistic, concentric-only leg presses and bench presses using loads corresponding to 20%, 30%, 40%, 50%, 60% of MIF (presented in randomized order), during which maximal instantaneous power was measured using force plates and position transducers. Subjects. Twenty healthy volunteers (mean ± SD; 12 men, 8 women, age: 31 ± 6 years, body mass: 72 ± 15 kg) consented to participate in this investigation. Test protocols and procedures were reviewed and approved by the Johnson Space Center’s Committee for the Protection of Human Subjects.

Procedures. Data were obtained using a leg press device (Nebula Fitness Equipment, Versailles, OH) and bench press power cage (Fitness Technology, Skye, SA, Australia). Both devices were equipped with a force plate (Kistler Instrument Corp., Amherst, NY) and position transducer (Fitness Technology). Loads for each exercise were determined using different loads based on a percentage of maximal isometric force (MIF). Unlike symbols denote significant (P<0.05) differences in power output between loads.

Results

Maximal Isometric Force MIF values are presented in Table 1.

Table 1. Maximal isometric force values (mean ± SD).

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<thead>
<tr>
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<th>Leg Press (N)</th>
<th>Bench Press (N)</th>
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<tr>
<td>Females (n = 8)</td>
<td>398 ± 53</td>
<td>188 ± 50</td>
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<tr>
<td>Males (n = 12)</td>
<td>764 ± 130</td>
<td>427 ± 90</td>
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<tr>
<td>Total (n = 20)</td>
<td>618 ± 212</td>
<td>331 ± 142</td>
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Figure 1. Peak power output (mean ± SE) during ballistic leg presses using different loads based on a percentage of maximal isometric force (MIF). *+* denotes trend (P=0.07) for difference in power output compared to 60% MIF load.

Figure 2. Peak power output (mean ± SE) during ballistic bench presses using different loads based on a percentage of maximal isometric force (MIF). Unlike symbols denote significant (P<0.05) differences in power output between loads.

Conclusions

Maximal isometric force (MIF), which requires little time and is inherently safe to perform, can be used as an alternative strength measure for determining the optimal load for power testing.

The optimal relative load for measuring peak power output (i.e., 30–40% MIF) is similar to that which is recommended when loading is based on 1-RM (i.e., ~30–1-RM).

References


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